UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD
Before Administrative Judges:

Michael C. Farrar, Chairman
Dr. Peter S. Lam
Dr. Paul B. Abramson

In the Matter of	Docket No. 72-22-ISFSI
PRIVATE FUEL STORAGE, LLC	ASLBP No. 97-732-02-ISFSI
(Independent Spent Fuel Storage Installation)	February 24, 2005

MEMORANDUM
(Providing a Publicly-Available Version
of Today's Board Decision on F-16 Aircraft Accident Consequences)

The Licensing Board has today issued a decision resolving the last issue remaining before it, which involves the potential effect of F-16 aircraft crashes into concrete and steel casks that would be located at the proposed Private Fuel Storage facility. Given the nature of that issue, some of the evidence before the Board, and the Board's discussion of that evidence, must for obvious reasons be designated, in the NRC's vernacular, as "safeguards" and thereby by law and regulation withheld from public disclosure. Accordingly, two different versions of our decision are being issued today -- one available to the public, and the other (the "official" one) available only to the litigating parties and to any reviewing tribunals.

Attached hereto is the publicly-available version of today's decision. It differs from the nonpublic version only in that its Part II contains a non-safeguards summary of the Board majority's reasoning on the crucial issues, rather than the full analysis in the non-public version.

In all other respects, the two versions are identical. Each is numbered by section, rather than consecutively from beginning to end -- thus, only the "B"-numbered Part II has different pagination (13 pages in the Public Version, 43 pages in the Safeguards Version). This public version also includes in toto the "D"-numbered dissenting opinion, which was framed to avoid including safeguards information.

With the issuance of this Memorandum and its Attachment, the Public Version of our decision -- which is clearly designated as such on each page -- is being made available electronically to the parties; it will then be made accessible electronically through a direct link on the agency's public web site (and will later appear on the agency's ADAMS electronic

document system) so that it will be readily available to any who are interested. The Safeguards Version, with sensitive information interwoven throughout its much longer Part II, may not be transmitted electronically, so hard copies are being provided to, and only to: (1) the parties who litigated this particular matter (the State of Utah, the Applicant PFS, and the NRC Staff); and (2) the NRC Commissioners (and subsequently any reviewing courts) who will consider and resolve any appeals from our decision.

Although there will be no public access to the Safeguards Version of today's decision, the Board intends to explore the extent to which there are non-sensitive portions of Part II of the decision that could be usefully extracted. If feasible, the Board eventually will prepare a redacted version that would be both published in the bound volumes of the periodic Nuclear Regulatory Commission Issuances and provided electronically in the agency's ADAMS system for public viewing and reference. If experience is any guide, any eventual redacted version, which would make more information available to the public, will take us some time to prepare because the parties' counsel and the agency's security experts will need to be heavily involved in the review process.

FOR THE ATOMIC SAFETY
AND LICENSING BOARD

[original signed by]
Michael C. Farrar, Chairman
ADMINISTRATIVE JUDGE

Rockville, Maryland
February 24, 2005

[BODY OF DECISION EXCLUDED]

Absent a further Commission directive, the Board's substantive role in the case is complete (the Farrar-chaired Board does intend later to work with the parties administratively to prepare a *Redacted Version* of this decision, and the Bollwerk-chaired Board is carrying out a similar task related to the proprietary aspects of the financial qualifications issue). For the final time, then, we thank the parties for their professional, high quality presentations and participation, while also commending to their attention our thoughts about possible settlement.

Pursuant to 10 C.F.R. § 2.760(a), this Final Partial Initial Decision will constitute the FINAL ACTION of the Commission within forty (40) days of this date unless a Petition for Review is filed in accordance with 10 C.F.R. § 2.786(b), or the Commission directs otherwise.

Within fifteen (15) days after service of this Final Partial Initial Decision (which shall be considered to have been served by regular mail for the purpose of calculating that date), any party may file a PETITION FOR REVIEW with the Commission on the grounds specified in 10 C.F.R. § 2.786(b)(4). Any such Petition for Review should also cover any interlocutory rulings of ours that were not previously appealable either by NRC Rule or by Commission Order. The filing of a Petition for Review is mandatory in order for a party to have exhausted its administrative remedies before seeking judicial review. 10 C.F.R. § 2.786(b)(1).

Within ten (10) days after service of a petition for review, any party to the proceeding may file an ANSWER supporting or opposing Commission review. 10 C.F.R. § 2.786(b)(3).

The petition for review and any answers shall conform to the requirements of 10 C.F.R. § 2.786(b)(2)-(3).

It is so ORDERED.

THE ATOMIC SAFETY
AND LICENSING BOARD

[original signed by]
Michael C. Farrar, Chairman
ADMINISTRATIVE JUDGE

Peter S. Lam *
ADMINISTRATIVE JUDGE

[original signed by]
Paul B. Abramson
ADMINISTRATIVE JUDGE

* As indicated at the outset, Judge Lam dissents from the result reached in the foregoing Initial Decision, and is therefore not signing it. His signed dissent follows, on pages D-1 to D-7.

Rockville, Maryland
February 24, 2005

Opinion of Judge Lam, Dissenting

I. Introduction

I dissent from the majority opinion for the basic reason that the proposed PFS facility has not been demonstrated to meet an established safety standard for accidental aircraft crash hazards. This safety standard, which was established in an earlier Board decision[1] and subsequently affirmed by the Commission,[2] requires that the PFS facility be designed to withstand aircraft crashes if the annual probability of such crashes exceeds one in one million (1×10^{-6} per year). The Board previously ruled in a partial initial decision[3] that the proposed PFS facility did not meet the 10^{-6} per year safety standard, and accordingly the Board did not approve the PFS license application at that time.

In this current proceeding, the Applicant has performed an extensive probability analysis and a structural analysis to rehabilitate its license application. As explained below, the Applicant's probability and structural analyses both suffer from major uncertainties. These uncertainties fundamentally undermine the validity of the analyses. Accordingly, I would hold that the Applicant has not met its burden of demonstrating that it has satisfied the 10^{-6} per year safety standard.

II. Discussion

A. Uncertainties in the Applicant's Probability Analysis

Three inter-related issues contribute significantly to the uncertainties in the Applicant's probability analysis: (1) the scarcity of F-16 crash data; (2) the quality of the F-16 crash data, as expanded by regression analysis; and (3) the sensitivity of the complementary cumulative distribution function (CCDF) to different fitting methods, and its large impact on the final calculated crash probability.

Issue 1: Scarcity of Documented F-16 Crash Data

First, there is no dispute by the parties that the data on F-16 crashes in general, and on crash impact speed and angle in particular, are sparse. Only 57 F-16 accident reports were deemed suitable for analysis by the Applicant, and only 15 reports have documented impact

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[1] LBP-01-19, 53 NRC 416 (2001).

[2] CLI-01-22, 54 NRC 255 (2001).

[3] LBP-03-04, 57 NRC 69 (2003).

speed. Even if Utah's challenges to the suitability of some of these reports were entirely disregarded, these reports collectively represent a small sample.

The uncertainties inherent in using a small data set were explored by the Board in this proceeding. The Board requested that the Applicant perform its analysis using only documented crash data from the 15 reports that contain documented impact speed to assess how sensitive the results might be to such a small data set. The Applicant's results[4] indicate that using such a small set of data would imply a crash probability exceeding the 10^{-6} per year safety standard, but that the standard errors of the estimate would be unreliably large. This of course is no surprise, as it only confirms the obvious: the use of a small data set leads to large uncertainties.

Issue 2: Quality of Expanded F-16 Crash Data

The scarcity of data, the Applicant asserts, necessitates the expansion of the small data set of documented impact speeds to a larger set of estimated impact speeds by using regression analysis. The uncertainties inherent in using a small data set are now compounded by the uncertainties introduced by the regression analysis. Note that the correlation coefficients in the Applicant's regression analysis are above 0.9, but not quite 1.0, indicating there is a good, but not perfect, fit of data. This implies that additional uncertainties are now being introduced by the regression analysis. The Applicant advocates the theory that the expanded set is as good as the original set, while Utah argues that the expanded set may not adequately represent the actual F-16 crash parameters. The truth probably lies somewhere between these two opposing positions.

The uncertainties inherent in the use of a small set of F-16 crash data, compounded by additional uncertainties introduced by regression analysis, must not be ignored for two important reasons. First, the Applicant's calculated crash probability (0.74×10^{-6} per year), even if assumed to be accurate and reliable (an assumption Utah vigorously challenges), leaves scant margin for error in meeting the 10^{-6} per year safety standard. Second, the Applicant's calculated crash probability is sensitive to small uncertainties introduced by how crash data is manipulated (see discussion of the CCDF curve below).

Issue 3: Sensitivity of CCDF Curve to Fitting

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[4] See State Exh. 278, Summary Table for Board's Requested Calculation, by PFS expert Dr. Cornell, August 20, 2004. See also Tr. 18078-102 (Cornell explaining exhibit).

The uncertainty raised by the third issue, namely how different methods of fitting the CCDF curve in the region of high impact speeds affect the final calculated crash probability, is also critical. Utah's expert Dr. Thorne, in State Exhibit 285,[5] indicates that by using actual discrete values of the CCDF for three particular impact speeds higher than the Applicant's threshold value, the annual probability of an F-16 crash breaching a spent fuel storage cask is 0.506×10^{-6} per year. This represents a significant increase from the Applicant's value of 0.375×10^{-6} per year, which is obtained by fitting the CCDF curve into a smooth curve between the aforementioned impact speeds.[6] This increase alone would bring the accidental F-16 crash probability to slightly above 1×10^{-6} per year, hence failing the 10^{-6} per year safety standard. This observation of CCDF sensitivity is important because it demonstrates quantitatively that the annual probability outcome is sensitive to a seemingly small uncertainty introduced by how crash data is manipulated.

B. Uncertainties in the Applicant's Structural Analysis

A singularly important but unresolved dispute with respect to the Applicant's structural analysis is the Applicant's declination to adopt the DOE ductility ratio standard[7] as the failure criterion for the spent fuel storage cask. The DOE ductility ratio standard was developed by a group of experts, assembled by the Department of Energy, to protect facilities containing radioactive or chemical materials from the hazards of an accidental aircraft crash. Experts from the Defense Nuclear Agency, Federal Aviation Administration, and Environmental Protection Agency participated in that development process, with an NRC expert having observer status.

The evidence provided by Utah persuasively shows that the concrete overpack of the spent fuel storage cask is exactly the type of structure (concrete structure with carbon steel shells) to which the DOE ductility ratio should be applied as a governing failure criterion. When, as a result of an F-16 crash, the strain in the carbon steel shells of the concrete overpack reaches the failure strain set by the DOE ductility ratio standard, the overpack should be considered to have failed in performing its intended function. All parties' analyses in the

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[5] State Exh. 285, Additional Probability Analyses, September 13, 2004.

[6] See Tr. at 18869-83 (Thorne explaining exhibit).

[7] See State Exh. 254, United States Department of Energy Standard (DOE-STD-3014-96) Accident Analysis For Aircraft Crash into Hazardous Facilities (Oct.1996).

evidentiary record show that the strain in the overpack's carbon steel shells significantly exceeds the DOE ductility ratio failure strain. Therefore the overpack is expected to fail in an F-16 crash scenario.

How this overpack failure would occur under the DOE ductility ratio standard, and how it would subsequently impact the stainless steel multi-purpose canister, has not been identified in this proceeding, despite numerous inquiries by Board members. This lack of clarity about how the overpack fails under the DOE ductility ratio standard is not a valid basis for asserting that the overpack would not fail. Nor is it a valid basis for asserting that the DOE ductility ratio standard does not apply to the overpack.

The caution urged by Utah's expert Dr. Sozen in advocating the adoption of the DOE ductility ratio standard for both the carbon steel shells of the overpack and the stainless steel canister should be heeded. As Dr. Sozen testified in this proceeding,[8] there are numerous uncertainties associated with how a structure would fail under aircraft crash impact. These uncertainties include: uncertain loading; the actual shape of the stress/strain curve; presence of residual stress; large strain gradients; presence of welds; potential fabrication and installation errors; and high strain rates. To appropriately deal with these uncertainties, the failure strain should be set as close as reasonable to the yield strain, namely to stay close to the elastic range. This rationale is the underlying premise of the DOE ductility ratio standard. Its adoption in this proceeding as the governing failure criterion for the concrete overpack, perhaps even for the stainless steel multi-purpose canister as urged by Utah, would have been prudent.[9]

The use of the DOE ductility ratio standard is also bolstered by the latest theory advanced by Utah regarding how Appendix F to section III of the ASME code should be applied

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[8] See Tr. at 16243-44 (Sozen).

[9] I do not join in the majority's belief that the DOE ductility ratio standard is merely a design tool, and that a significant violation of that standard will pose no threat to the concrete overpack or the stainless steel canister. However, even if the DOE ductility ratio failure strain were merely a design failure strain, prudent safety practice (and the position advocated by Utah) would still require preventing the strain in the overpack and the canister from greatly exceeding the ductility ratio failure strain. To greatly exceed a design failure strain is to erode whatever conservatism is incorporated in the design.

to determine the failure strain of the multi-purpose canister.[10] Here, Utah argues persuasively that using material properties for stainless steel provided by the ASME code, taking into account neither strain hardening nor transformation of engineering strain to true strain, would predict a failure strain of less than 10 percent. This 10 percent value is significantly less (by a factor of about 4) than the value the Applicant used in its analysis for failure strain in the stainless steel multi-purpose canister.

III. Conclusion

Simply put, in contrast to the demonstrated robust safety margin against design seismic events found in our earlier decision LBP-03-08,[11] the proposed PFS facility does not currently have a demonstrated adequate safety margin against accidental aircraft crashes. Even if the Applicant were to overcome all of the aforementioned uncertainties in its analyses, the proffered probability of 0.74×10^{-6} per year of aircraft crashes leading to unacceptable consequences has a margin of only 26 percent when measured against the safety standard of 1×10^{-6} per year. This 26 percent margin rapidly disappears when one or more of the aforementioned uncertainties are considered. For example, if either the documented impact speeds alone were used, or the DOE ductility ratio standard were adopted as the concrete overpack and multi-purpose canister failure criterion, the proposed PFS facility would immediately fail the 10^{-6} per year safety standard.

This lack of adequate safety margin is a direct manifestation of the fundamentally difficult situation of the proposed PFS site: 4,000 spent fuel storage casks sitting in the flight corridor of some 7,000 F-16 flights a year. The venerable four-factor aircraft crash formula in NUREG-0800,[12] which has been used for years to steer reactor license applicants away from difficult sites facing significant aircraft hazards, has already indicated once[13] that the proposed PFS site fails to meet the safety standard of 10^{-6} per year.

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[10] See State of Utah's Reply Findings of Fact (Nov. 19, 2004) at 15-25; State of Utah's Response to Board Order Directing Clarification of Record (Dec. 8, 2004).

[11] 57 NRC 293 (2003).

[12] NUREG-0800, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants (Rev. 2) (July 1981).

[13] See LBP-03-04, 57 NRC 69 (2003).

The Applicant's current analyses, which are fundamentally undermined by large inherent uncertainties and narrow safety margins, should not be relied upon to demonstrate the safety of the proposed site. More needs to be done. The Applicant should demonstrate that a breached spent fuel storage cask would not result in a site-boundary radioactive dose exceeding regulatory limits, or should implement other remedies such as the installation of physical barriers. Such a decisive demonstration, or the implementation of genuine remedies, would ensure the adequate protection of public health and safety.

[original signed by]
Peter S. Lam
Administrative Judge